U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE

HEARING CHARTER

H.R. 5143, the H-Prize Act of 2006

Thursday, April 27, 2006
9:30 a.m. to 11:30 a.m.
2318 Rayburn House Office Building

1. Purpose

On Thursday, April 27, 2006, the House Science Committee will hold a hearing on H.R. 5143, *The H-Prize Act of 2006*. The bill is intended to create a new incentive to achieve scientific and technical breakthroughs required to make the transition to a hydrogen economy.

2. Witnesses

- **Mr. Phillip Baxley** is the President of Shell Hydrogen, L.L.C., a separate business unit established by Shell in 1999 to pursue new business opportunities in hydrogen fuel and fuel cells.
- **Dr. David Bodde** is the Director of Innovation and Public Policy at Clemson University's International Center for Automotive Research (ICAR). He was a member of the National Academy of Engineering Committee on Alternatives and Strategies for Future Hydrogen Production and Use, which issued the 2004 report *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*.
- **Dr. Peter Diamandis** is the Chairman of the X Prize Foundation, a non-profit organization dedicated to fostering innovation through the use of competitions. The foundation awarded its $10 million Ansari X Prize to promote the formation of a commercial spaceflight industry. Prizes for genomics, energy and education are under development.
- **Dr. David L. Greene** is a corporate fellow of Oak Ridge National Laboratory with the Center for Transportation Analysis, National Transportation Research Center. He is an expert in transportation and energy policy issues.

3. Overarching Questions

The hearing will address the following overarching questions:

1. Are any changes needed in H.R. 5143?
2. Does H.R. 5143 provide the right incentives to address the most significant technical barriers to the widespread use of hydrogen as a fuel source?

3. How can the Department of Energy (DOE) best use prize competitions to complement more traditional research support mechanisms, including contracts and grants, as a way to develop the hydrogen economy?

4. Brief Overview

On April 6, 2006, Research Subcommittee Chairman Bob Inglis; Science Committee Chairman Sherwood Boehlert; Environment, Technology and Standards Subcommittee Chairman Vernon Ehlers; Congressman Roscoe Bartlett; Congressman Michael McCaul; Congressman Daniel Lipinski; and nine other co-sponsors introduced H.R. 5143, *The H-Prize Act of 2006*.

Inspired by the successful Ansari X Prize, which awarded $10 million to Burt Rutan for suborbital space flight, the H-Prize is designed to accelerate the drive to a hydrogen economy by creating an incentive for new, entrepreneurial players to join the race to break down technical and other barriers to the advancement of hydrogen technologies.

The Science Committee, at the Administration's request, created a prize program for NASA in the NASA Reauthorization Act of 2005. The language of H.R. 5143 is largely based upon that of the NASA Act (P.L. 109-155).

A summary of H.R. 5143 and a section-by-section analysis are included in Part 7 of this charter.

Hydrogen gas is considered by many experts to be a promising fuel, particularly in the transportation sector. When used as a fuel, its only combustion byproduct is water vapor. The widespread adoption of hydrogen as a transportation fuel has the potential to reduce or eliminate air pollution generated by cars and trucks.[1]

However, unlike harvested wood or mined coal, the hydrogen gas used as a fuel is not a naturally occurring energy resource. Hydrogen must be produced from hydrogen-bearing compounds, like water or natural gas, and that requires energy—and, unlike gasoline, more energy is always required to produce it than is recovered when hydrogen is burned in a fuel cell. Hydrogen has

[1] The Science Committee and its Subcommittees have held numerous hearings on the use of hydrogen since the announcement of the FreedomCAR Initiative by then-Secretary of Energy Spencer Abraham on January 9, 2002. The FreedomCAR program was centered on fuel cell vehicles, which use hydrogen as fuel.
The full committee held the following hearings:
February 7, 2002 - Full Committee *Hearing on The Future of DOE's Automotive Research Programs*
April 2, 2003 - Full Committee *Mark-Up of HR 238; Energy Research, Development, Demonstration, and Commercial Application Act of 2003*
March 5, 2003 - Full Committee *Hearing on The Path to a Hydrogen Economy*
March 3, 2004 - Full Committee - *Hearing Reviewing the Hydrogen Fuel and FreedomCAR Initiatives*
The Energy Subcommittee held the following hearings:
June 26, 2002 - Subcommittee on Energy *Hearing on FreedomCar: Getting New Technology into the Marketplace*
June 24, 2002 - Subcommittee on Energy *Field Hearing Fuel Cells and the Hydrogen Future*
There was one hearing held jointly with the Energy Subcommittee and the Research Subcommittee:
July 20, 2005 - Joint Hearing - Subcommitee on Energy and Subcommittee on Research - *Fueling The Future: On The Road To The Hydrogen Economy*
In addition, these programs were also subject to scrutiny during hearings on budget priorities and within the Administration's Climate Change Technology Program. Transcripts of these hearings are available on the Committee website or from the Congressional Research Service.

the potential to reduce America's dependence on foreign oil, but the degree to which hydrogen will displace foreign energy supplies depends on what energy source is used to generate hydrogen gas in the first place.

If hydrogen can be produced economically from energy sources that do not release carbon dioxide into the atmosphere—from renewable sources such as wind power or solar power, from nuclear power, or possibly from coal with carbon sequestration, then the widespread use of hydrogen as a fuel could make a major contribution to reducing the emission of greenhouse gases.

While the promise of hydrogen is great, so are the technical challenges. Experts suggest that major advances will be required across a wide range of technologies for hydrogen to be affordable, safe, cleanly produced, and readily distributed. The production, storage, and use of hydrogen all present significant technical challenges. While DOE research programs have produced promising advances, those programs are still a long way from meeting their goals of developing economically viable hydrogen technologies. Indeed, the American Physical Society in a 2004 report stated that "no material exists today that can be used to construct a hydrogen fuel tank that can meet the consumer benchmarks," that is for affordably storing enough fuel on-board a car or truck to enable a long enough ride between refuelings.

5. Issues

What could be gained by establishing a prize program to promote advances in using hydrogen as a fuel?

Traditionally, DOE has relied upon established researchers in national labs, industry, and academia to carry out its mission of developing energy technologies for use by the private sector. Most commonly, DOE identifies a technical hurdle and then issues research solicitations of varying specificity. These solicitations detail the type of technologies the agency wants to fund and the performance goals the agency anticipates the technology will meet when introduced to the marketplace. For example, DOE might issue a solicitation for automotive fuel cell technologies. Such a solicitation may include the requirement that the fuel cells be a particular type of fuel cell, or may be targeted at known technical problems. Projects are then selected against the criteria set out in the original solicitation. DOE may use grants, cooperative agreements or contracts to carry out projects, and industrial participants are required to share costs.

Prizes would presumably involve less direct DOE involvement in day-to-day research activities than would any of the traditional technology development routes. Instead, DOE would offer a prize for the development of a particular technology or for a particular achievement, and then would wait to see what contestants produced. Proponents of prizes argue that this would be less costly and less bureaucratic, and might spur more creative thinking. In addition, they argue that inventors and entrepreneurs (as opposed to national labs or major energy companies) would be more inclined to compete for a prize than compete for more traditional grants and contracts.

Proponents of prizes further argue that traditional peer review processes tend to favor proposals that seem safe over those that may produce surprising and potentially more innovative results.

Many have commented – in a wide variety of contexts – that the federal procurement system can be intolerant of risk, and can place costly bureaucratic demands on private-sector contractors.

Other advocates cite prizes as having additional benefits. Prizes are seen as mobilizing much more private capital than matching grants, since numerous contestants all spend their own money on technology development while they vie for the same funds. (Traditional grant processes usually have at most a one-to-one funding match.) Prizes allow the federal government to shift much of the risk and the financial burden of technology development from the government to the contestants. For some, the most important aspect of prizes is their ability to educate, inspire, and mobilize the public for scientific, technological, and societal objectives.

How does a prize program need to be structured to be successful?

Prize contests can be less clear-cut than they first appear. Problems can develop in the design of the contest, the selection of a winner, and in the aftermath. A National Academy of Engineering (NAE) panel examining the use of prizes by federal agencies[2] suggested the following design principles for prize programs:

- Treatment of intellectual property resulting from prize contests should be properly aligned with the objectives and incentive structure of the prize contest.
- Contest rules should be seen as transparent, simple, fair, and unbiased.
- Prizes should be commensurate with the effort required and goals sought.

DOE would have to design its prize contests carefully. The goal for which the prize was being awarded would have to be clearly enough described that contestants (and DOE) had a firm sense of what DOE was seeking and why. On the other hand, too detailed a description by DOE would limit the kinds of ideas that a contest could yield. A very detailed description would not end up being much different than contract specifications.

The selection of a prize winner can also be difficult. Judges need to be open to unexpected ideas. There are historical examples of revolutionary ideas losing prize contests because the judges were not open to unexpected ways of achieving the stated goals.[3] Decisions also need to be made about who is allowed to compete for a prize. For example, H.R. 5143 does not allow federal employees to compete except on their own time. It is silent on whether entities receiving federal funding can compete. Should entities that are already receiving federal backing be able to compete for a federally funded prize?

The award of a prize does not guarantee, by itself, that the social benefits of the technology will be realized or that the technology will be commercialized. In the wake of the award of any prize, DOE would not be the entity to decide how to put a winning idea into actual use. A prize winner

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[2] *Concerning Federally Sponsored Inducement Prizes in Engineering and Science*, Steering Committee for the Workshop to Assess the Potential for Promoting Technological Advance Through Government-Sponsored Inducement Prizes in Engineering and Science, Washington, DC: National Academy of Engineering (1999).

[3] The best-selling book *Longitude* by Dava Sobel describes just such a case. John Harrison developed method for measuring exact longitude based upon a clock that kept time accurately even during a ship's pitching and rolling at sea. However, despite the proven test of his invention at sea, the group administering the prize (the Board of Longitude) refused to award him the prize money – which historians attribute to the Board's domination by astronomers who favored a rival, astronomy-based method of determining longitude.

might not have the financial wherewithal or even the technical capacity to actually turn their winning idea into a viable product. It may therefore be necessary for DOE to take additional actions to promote technologies after the award of prizes.

Finally, it is unclear whether prizes would be a less costly way of doing business once all the costs DOE would have to incur in running a successful contest are taken into account.

How dependent upon prizes should DOE be for the development of critical technologies?

Prizes are being proposed as a supplement to, not a substitute for traditional R&D programs. Indeed, H.R. 5143 makes that point explicitly in the last section of the bill. Traditional programs are especially important if developing a specific technology on a specific timetable is critical to a DOE objective, such as development of a coal-fired power plant with zero carbon emissions. The timing of technology development may be easier to control through traditional solicitations and research awards.

What kinds of goals are appropriate for prize contests?

Prizes benefit from clear-cut goals. In general, the more complex the goal of a contest, the more complex DOE's role would likely be. (For example, evaluating a set of integrated technologies that radically change hydrogen distribution and use is a more demanding undertaking than evaluating the performance of a hydrogen storage tank.) At some point, the complexity might eliminate the advantage of a contest over traditional means of technology development. If appropriately designed, prize contests can reveal important information, particularly about the failures that emerge upon integration of subsystems, that can inform the plans and priorities of the Department's on-going hydrogen research program.

How large does a prize need to be to induce investment?

One of the key objectives of some prizes is to induce investment. Often, the prestige of having won the prize is seen as having greater value than the prize itself. Winning contestants, as in the Ansari X Prize, have been known to spend more in an effort to win a prize than they gained from the prize itself, and several contestants that did not win also invested. Thus, the prize level must be high enough to garner attention and prestige. But at the same time the prize amount must be realistic enough to be appropriated. Also, if there is a limited pool of potential contestants, even a large prize may not induce more investments.

6. Background

Prizes

There are two types of technology prizes: recognition and inducement prizes. Recognition prizes are post-facto prizes, intended to reward a past accomplishment. The Nobel Prizes are the most famous prizes of this type. Inducement prizes are awarded to an individual or group who has the best entry in a defined contest or who first meet some specified technical goal.

The NAE report specifically recommended that Federal agencies experiment with inducement prizes. Among other things, inducement prizes may best serve "to 'stretch' the state of the art in technology." As an example, the Defense Advanced Research Projects Agency awarded $2

million in 2004 for its Grand Challenge Prize to Stanford University researchers for their design and construction of an autonomous ground vehicle that was able to navigate a 131.2 mile course through the Mojave Desert.

Typically, inducement prize contests are either best-entry contests or goal-oriented contests. H.R. 5143 includes both types of prizes. In a best-entry contest, a prize is given for the best entry submitted during a given time period, even if the winning entry in a given year falls short of the ultimate technical objective. DOE's Solar Decathlon competition, held on the National Mall last summer, is a good example in the energy R&D arena. Decathlon teams must design and build fully-functioning houses powered exclusively by the sun.

By contrast, goal-oriented contests have a clear technical objective. The prize is awarded only if a pre-determined goal is met and verified. The $10 million Ansari X Prize was awarded in 2004 after SpaceShipOne, a privately built three-person craft, made a required second flight 62 miles (100 km) above the surface of the Earth within a two-week period. The ability to meet a bright-line technical objective does not necessarily guarantee economic viability.

Inducement Prizes can be divided further into four different types of objectives:

- ***New or Best Invention*** prizes reward the first new technology or technique that meets some technical objective. The Ansari X Prize falls in this category.
- ***New Application*** prizes reward refining or integrating existing technologies to meet a new objective. The previously mentioned DARPA Grand Challenge Prize is this type of prize.
- ***Performance Improvement*** prizes reward improving the performance of an existing product used for an existing application.
- ***Technology Diffusion*** prizes reward the diffusion of new innovation, for example requiring that a specified number of units be sold in the commercial marketplace.

H.R. 5143 contains three prizes. The first is a set of $1 million prizes for advancements in hydrogen storage, hydrogen production, hydrogen use and hydrogen distribution. This is a best-entry contest that rewards performance improvements. The second prize rewards prototypes that meet objective contest criteria established in advance. This is a $4 million goal-oriented contest for a new application, namely the use of hydrogen in vehicles or other energy use applications. The third prize is a $10 million goal-oriented contest for the best invention that leads to transformational changes in the distribution or production of hydrogen. Winners of the third prize would become eligible for up to $90 million in matching funds for every dollar of private funding raised by the winner for commercialization of their winning technology.

Existing Energy Prizes

Section 1008 of the Energy Policy Act of 2005 authorizes DOE to spend $15 million to carry out a more general prize program for "grand challenges of science and technology" including to reduce U.S. dependence on foreign oil. DOE is said to be studying this authority for use in the hydrogen arena. In addition, the Federal government already operates a number of competitions and contests in the energy R&D area. For example, DOE's Solar Decathlon, mentioned above,

is a best-entry "design" competition.[4] Entrants must provide enough solar power to perform all the functions Americans have come to expect at home—washing clothes, running the dishwasher, powering computers, and, of course, maintaining a comfortable temperature. Winners are selected in subcategories—architecture, livability, comfort, power performance, etc.—and an overall winner is determined as well. Competitions of this type are often particularly useful for demonstrating how a technology can be incorporated into a commercially attractive product. In fact, the University of Colorado's winning *BioS[h]IP* house was designed for and will be delivered to a client.

As with the Solar Decathlon, many existing energy R&D prize competitions focus on student competitions. In DOE's Future Truck competition, teams of students from 15 top North American universities refined their reengineered Ford Explorers to achieve lower emissions and at least 25 percent higher fuel economy, without sacrificing performance, utility, safety, and affordability. DOE and Natural Resources Canada help sponsor the North American Solar Challenge, a competition to design, build, and race solar-powered cars. Solar Challenge teams, primarily from universities, compete in a 2,500 mile race from Austin, Texas to Calgary, Alberta. A number of American Solar Challenge teams go on to compete in the biennial World Solar Challenge – a 3,000 kilometer (1,863 miles) race across Australia. And the American Forest and Paper Association and DOE Office of Industrial Technologies have sponsored student competitions to find novel uses for the more than two billion tons of waste every year produced by the forest products industry.

In at least one recent case, a government-sponsored energy competition involved industry contestants. The California Energy Commission and the Environmental Protection Agency's ENERGY STAR program jointly sponsored Efficiency Challenge 2004, an international design competition for energy efficient AC/DC power supplies. In two award categories, power supplies were judged on different criteria. The market-ready category weighed practical factors such as power supply cost and packaging, along with energy efficiency. In the open category, power supplies entered were evaluated without any cost or packaging constraints. This latter category was intended to showcase the most efficient power supply designs from both industry and academia.

Hydrogen

In his 2003 State of the Union speech, President Bush announced the creation of a five-year, $1.2 billion Hydrogen Fuel Initiative, which built on the FreedomCAR initiative announced in 2002. Together, the initiatives aim to enable the transition to a hydrogen-based transportation economy, by developing technologies for the production, transportation and distribution of hydrogen, and the vehicles that will use the hydrogen. Fuel cell cars running on hydrogen would emit only water vapor from the tailpipe and, if domestic energy sources were used to produce the hydrogen, would not be dependent on foreign fuels. The Administration has requested $289.5 million for the Hydrogen Fuel Initiative in Fiscal Year (FY) 2007, an increase of $41.8 million over the FY 2006 funding level. Federal funding for the Hydrogen Initiative totals $631.7 million for FY 2004 – 2006, about 52 percent of the proposed initiative. Of that total, $121.5 million (19 percent) has been earmarked by Congress for specific projects.

[4] The Solar Decathlon was the subject of a November 2, 2005 Energy Subcommittee hearing, *Winning Teams and Innovative Technologies from the 2005 Solar Decathlon*.

Major advances are needed across a wide range of technologies if hydrogen is to be affordable, safe, cleanly produced, and readily distributed. The production, storage and use of hydrogen all present significant challenges.

- **Lowering the cost of hydrogen**: At present, hydrogen (when produced from its most affordable source, natural gas) is three to four times more expensive to produce than gasoline. Current DOE research efforts seek to lower that cost enough to make fuel cell cars cost-competitive with conventional gasoline-powered vehicles by 2015; and to advance the methods for producing hydrogen from renewable resources, nuclear energy, and coal.
- **Creating effective hydrogen storage**: Current hydrogen storage systems cannot deliver the vehicle driving distance that automakers say consumers demand. New technology is needed.
- **Creating affordable hydrogen fuel cells**: Fuel cell-based propulsion is now up to 10 times more expensive than internal combustion engines. A major goal of current DOE research efforts is to reduce the cost of fuel cell propulsion to affordable levels.

Analyses of the Hydrogen Fuel Initiative by the American Physical Society (APS)[5] and the National Academies of Science (NAS)[6] note that meeting the goals of the overall hydrogen initiative will require fundamental breakthroughs – not just incremental improvements. For example, storing hydrogen gas requires too large a volume for practical on-board storage in vehicles. New materials would be required to store hydrogen in more condensed form and release it when needed—a very difficult technical problem. The APS study states, "No material exists today that can be used to construct a hydrogen fuel tank that can meet the consumer benchmarks." The NAS estimated that fuel cells themselves would need a ten- to twenty-fold improvement before fuel cell vehicles become competitive with conventional technology. Current fuel cells wear out quickly, and lifetimes are far short of those required to compete with a gasoline engine. Large improvements have been made since the NAS report was released, but additional improvements are still needed. DOE estimates that roughly a five-fold decrease in fuel cell cost will be required, while at the same time increasing performance and durability.

Both reports recommended changes to the hydrogen initiatives, particularly arguing for a greater emphasis on basic, exploratory research because of the significant, perhaps insurmountable, technical barriers that must be overcome. DOE has responded, in part, by expanding the hydrogen program to include work in the Office of Science focused on design of new catalysts, solar hydrogen production, and the study of ion transport in fuel cell membranes.

Even if the technology advances to a point at which it is competitive, the transition to a hydrogen economy will require an enormous investment to create a new infrastructure. Changes in regulation, training and public habits and attitudes will also be necessary. Estimates of the cost

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[5] *The Hydrogen Initiative*, APS Panel on Public Affairs, Washington, DC: The American Physical Society (March 2004).

[6] *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs*, Committee on Alternatives and Strategies for Future Hydrogen Production and Use, Washington, DC: National Research Council and the National Academy of Engineering (2004).

of creating a fueling infrastructure (replacing or altering gas stations) alone are in the billions of dollars.

As currently envisioned, the transition won't happen quickly. According to the NAS study, significant sales of hydrogen vehicles are unlikely before 2025 even under the most optimistic technology assumptions.

7. Section-by-Section Description of H.R. 5143

Section 1. Short Title.

The H-Prize Act of 2006.

Sec. 2. Definitions.

Sec. 3. Prize Authority.

Requires the Secretary of Energy to create a prize to advance the research, development, demonstration and commercial application of hydrogen energy technologies.

Requires the Secretary to advertise the prize competitions widely to encourage broad participation, including a specific direction to announce the prize competitions through publication of a Federal Register notice. Requires the Secretary to enter into an agreement with a private, non-profit entity to administer the prize competitions. Authorizes the Secretary to use funding directly appropriated for such purposes to DOE or other agencies and to accept funds provided by private entities or individuals. Prohibits the announcement of any prize competition until sufficient funds are available. Sunsets the authority to award prizes in 2017.

Sec. 4. Prize Categories.

Defines prize categories for:

(i) **Components or Systems**. Establishes up to four $1 million prizes awarded every other year to the best technology advancements in components or systems related to hydrogen production, hydrogen storage, hydrogen distribution, and hydrogen utilization. Provides the Secretary the discretion to reduce the amount or number of prizes based upon the availability of funds.

(ii) **Prototypes**. Establishes one $4 million prize for prototypes of hydrogen-powered vehicles or hydrogen-based products that best meet or exceed objective performance criteria. Awards prototype prizes in years alternate with the technology advancements prize. Prohibits the Secretary from awarding the prize if no entrant meets the objectively defined performance criteria.

(iii) **Transformational Changes**. Establishes a $10 million prize for transformational changes in technologies for the production and distribution of hydrogen that meet or exceed far-reaching objective criteria. Authorizes the Secretary to provide up to $90 million more in matching funds for every dollar of private funding raised by the winner for the continued development of their winning technology. Authorizes prize winners to accept these additional funds as cash or as a government contract equivalent to the prize amount. Limits the total award to $100 million.

Requires the Secretary to establish contest criteria through consultation with the Hydrogen Technical Advisory Committee, other federal agencies including the National Science Foundation, and private organizations including the National Academy of Sciences. Requires the Secretary to appoint contest judges from the private sector and agencies outside DOE. Excludes judges who may have a personal or financial relationship with any contest participant.

Sec. 5. Eligibility.

Requires contestants to register through the process published in the Federal Register. Requires contestants be incorporated and maintain a primary place of business in the U.S. if a private entity, or must be a U.S. citizen if an individual. Excludes from participation any Federal entities or Federal or national lab employees while on duty.

Sec. 6. Intellectual Property.

Waives claims by the Federal government to any intellectual property rights derived from participation in the prize competitions.

Sec. 7. Liability.

Requires contestants to waive claims against the Federal Government resulting from participation in prize competition activities. Requires contestants to have liability insurance against damages resulting from participation in any prize competition activity and to name the Federal Government as an additional insured entity.

Sec. 8. Authorization of Appropriations.

Authorizes $55 million for each of fiscal years 2007 through 2016. Limits the use of appropriated funds for administrative expenses to no more than $1 million in any fiscal year.

Sec. 9. Nonsubstitution.

Expresses a sense of the Congress that the prize competitions shall not act as a substitute for any R&D programs.

8. Witness Questions

Mr. Phillip Baxley , Dr. David Bodde, Dr. David L. Greene

- Are there any changes you would recommend making to H.R. 5143?
- Does H.R. 5143 provide the right incentives to address the most significant technical barriers to the widespread use of hydrogen as a fuel source?
- How can the Department of Energy (DOE) best use prize competitions to complement more traditional research support mechanisms, including contracts and grants, as a way to develop the hydrogen economy?

Dr. Peter Diamandis

- Are there any changes you would recommend making to H.R. 5143?

- What are the advantages of using prize programs to encourage technological progress in areas like the use of hydrogen as a fuel source?